Metal Particle Melting and Solidification for Powder Based Additive Manufacturing using the Optimal Transportation Meshfree Method

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ABSTRACT

Selective Laser Melting (SLM) is an additive manufacturing (AM) process, where a powder bed is partially melted. Layer by layer, complex 3-dimensional geometries can be produced including overhangs where the non-melted powder acts as a support structure.

Even today the multiple interacting physical phenomena of the SLM process are not yet fully understood. Still, the material and process development mainly relies on experimental studies which are costly and time intensive. Computational simulation tools offer the potential to gain a deeper understanding of the interaction between the process, the structure and the final properties. This can help to find optimal process parameters and opens the possibility to individualize additively manufactured products.

The melting of powder particles leads to extremely large deformations. Using conventional mesh based simulation tools, like the FEM, ill-shaped elements and hence degenerated computations can occur. Galerkin meshfree methods eliminate the mesh dependency by employing a more flexible relation between integration points and nodes. The Optimal Transportation Meshfree (OTM) method [1] is a novel Galerkin meshfree approach which simplifies the computational modelling of the melting process of many particles towards a single product.

Based on the OTM approximation scheme an approach to account for the phase transition and the fusion of particles will be presented. Furthermore, the solidification process [2] is modelled in order to show induced residual stresses. These stresses can yield to undesired deformations which can destroy additively manufactured parts. Some examples demonstrate the possibilities of the developed approach to understand the mechanism of SLM processes.

REFERENCES

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